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DOI: https://doi.org/10.12759/hsr.40.2015.2.151-173

Originally published at:
Westermann, Andrea (2015). Geology and world politics: mineral resource appraisals as tools of geopolitical calculation, 1919-1939. Historical Social Research - Historische Sozialforschung, 40(2):151-173.
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Geology and World Politics: Mineral Resource Appraisals as Tools of Geopolitical Calculation, 1919-1939

Andrea Westermann *

Abstract: *»Geologie und Weltpolitik: Rohstoffschätzungen als Instrumente geopolitischen Kalküls, 1919-1939«*. How is nature transformed into natural resources? Histories analyzing the state sciences of agriculture and forestry in the eighteenth and early nineteenth centuries showed that these sciences redefined nature as natural resources by making them amenable to cameralistic calculation, bookkeeping and accountability. Against this background, my first line of inquiry is exploring how, over the twentieth century, nonfuel mineral resource appraisals, i.e. attempts to quantify the metal content of the earth's crust, became the first hold that societies took on earth matters, transforming them into mineral resources. My second objective is to describe and explain a widening of scope. Around 1900, geologists and other mineral resource experts began to appraise minerals on a global scale and survey trends in the worldwide production and consumption of minerals. I argue that, after World War I, states started to use global mineral resource appraisals as tools of geopolitical calculation, aimed at measuring and managing both natural resources and state power relations. The global perspective was only one reason why mineral resources became amenable to economic and political management on a vast scale, though. In addition, global mineral resource supply and estimates had to be cast and discussed in an explicitly functionalist language in order to fit the interwar technocratic ideas of planning and maintaining world order.

Keywords: History of the earth sciences, technocracy, international relations, globalization.

1. Introduction

Minerals are only marketable after investments of large amounts of capital, energy and labor. To become commodities, they need what contemporaries soon characterized as an entire supply system on an international scale: states, private companies, and science collaborating to satisfy the world's hunger for minerals, thereby forming new alliances, institutions and regulations. Experts

* Andrea Westermann, Historical Seminar, University of Zurich, Karl Schmid-Strasse 4, 8006 Zurich, Switzerland; andrea.westermann@hist.uzh.ch.

Historical Social Research 40 (2015) 2, 151-173 │© GESIS
DOI: 10.12759/hsr.40.2015.2.151-173

have claimed that the turn of the twentieth century marked a new era for the output of the system. In 1931, University of Wisconsin Professor Charles Kenneth Leith outlined the historical change taking place by listing some of the records that had just been broken: “Few realize […] the fact, for instance, that in a hundred years, the output of pig iron, copper and mineral fuels has increased a hundredfold; that more mineral resources have been mined and consumed since the opening of the century than in all preceding history” (Leith 1970 [1931], 34). This trend continued. Both the growth rates and the output figures of major metals rose exponentially in the second half of the twentieth century (Wellmer, Dalheimer and Wagner 2007, 188). By the end of that century, the amount of metal ores and other industrial minerals extracted each year had increased by a factor of 27 compared to 1900 (Krausmann et al. 2009, 2699). How did the systematic and international supply of mineral resources develop over the late nineteenth and twentieth centuries, creating an ever-increasing stream of metal raw materials?

We know a lot about the history of specific mining regions, mining education and technologies (Ochs 1992; Hovis and Mouat 1996; Burt 2000; Brianta 2000; Lingenfelter 2003; Isenberg 2005; Laboulais 2008). Historians have given us accounts of particular mineral raw materials and analyses of the industries or specific mining firms (Prain 1975; Harvey 1981; Yergin 1991; Nest 2011). Fuel and nonfuel minerals have been addressed as pertaining to the infrastructure of global commodity chains (Innis 1933, 18; Topik and Wells 2012, 625). Several analyses of US mineral resource policies also exist (Eckes 1979; Priest 2003). But how is nature transformed into mineral resources in the first place? While this question focuses on foundational concepts and practices for the overall system of supply and its capacity to grow, research on the history of science or environmental history has only started to address the problem. Günter Bayerl (1994), Henry E. Lowood (1990) and James C. Scott (1998) showed that the state sciences of agriculture and forestry in the eighteenth and early nineteenth centuries aimed at redefining nature as natural resources by making nature amenable to cameralistic calculation, bookkeeping and accountability (Porter 1994). Drawing on their work, I explore, in a first line of inquiry, how, over the twentieth century, nonfuel mineral resource appraisals, i.e. estimations of the metal content of the earth’s crust, became the first hold that societies took on earth matters, transforming them into mineral resources (Haller, Höhler and Westermann 2014; for the history of oil estimates, see Bowden 1985; Gautier 2000; Graf 2014; Priest 2014).

My second objective is to describe and explain a new function that mineral resource appraisals acquired for politics in the early twentieth century. Around 1900, geologists and other mineral resource experts began to appraise minerals on a global scale and survey trends in international mineral production and consumption more frequently. After World War I, a small wave of books and essays appeared including *International Control of Minerals* (Mining and Met-

allurgical Society of America 1925); *Mineral Resources and their Effect on International Relations* (Bain 1930); *World Minerals and World Politics. A Factual Study of Minerals in Their Political and International Relations* (Leith 1970 [1931]); *The Mineral Sanction as an Aid to International Security* (Holland 1935); and *Die mineralischen Bodenschätze als weltpolitische und militärische Machtfaktoren* (Friedensburg 1936).

These endeavors gained unprecedented support: Global mineral resource appraisals attracted the attention of politics like never before. Industrial states started to compare their inventories of nature with those of other countries as a means to measure state power and determine and manage power relations. "World politics," as the emerging field of international relations was known in the interwar years, took up the reasoning, numbers and world depictions provided by mineral resource estimates. I argue that mineral resources appraisals, besides being cameralistic tools to account for and manage one's own nature capital, also became instruments of geopolitical calculation. Global mineral resource knowledge inextricably linked knowledge about the earth with knowledge about the world and hence was suited to become "global power knowledge" (Krige and Barth 2006).

But the globalization of mineral resource appraisals was only one reason why mineral resources became amenable to economic and political management on a vast scale, beyond the nation state (section 3). In addition, global mineral resource supply and estimates had to be cast and discussed in an explicitly functionalist language (sections 4 and 5) in order to fit interwar technocratic ideas of planning and maintaining world order (section 6). Before unfolding the argument, let me explain more about the nature of mineral resource appraisals (section 2).

2. Mineral Resource Appraisals: Combining Natural and Social Scientific Knowledge

There are three aspects of mineral resource appraisals. First, geologists have to find mineral ore deposits through geological, geophysical and geochemical exploration, then determine their size and ore grade, i.e. the actual metal content. It is not enough, however, to simply localize mineral occurrences of a certain element and determine their geological extension. One has to know whether, how, and at what cost these occurrences could be made available for human use. A second problem therefore is to take into account the development of mining technology, mine organization, production and transportation costs. Mining capacities, mine organization and production costs mostly depend on how deep beneath the surface the ore deposits are located. Low and high-grade ores need different, cost-determining refinement techniques. Last but not least, one needs to forecast world mineral consumption. Mineral resource appraisals

have to take into account the future demand for international metal raw materials and world market prices. After all, only those minerals recoverable at a profit now or in the near future are counted as 'reserves.'[1] As to mineral resource appraisals, a division of labor was soon established: known global mineral reserves to be profitably mined are currently appraised by the mineral mining and trading industry, whereas the estimation of submarginal mineral reserves and unknown mineral resources in weakly explored territories are, as a rule, inferred by state geologists and academic research (Wellmer and Becker-Platen 1999, 117).

Consequently, geological, technical and economic factors need to be combined in order to appraise both the size and 'lifetime' of the mineral resources available to a single mine, a larger mining district or state territories. Mineral resource estimations include forecasts about societies' future development (for the impact of social scientific knowledge on the earth sciences, see also Oreskes, this issue). Thus geologists pointed out early on that 'ore,' 'ore deposit' and 'ore reserves' were dynamic, constructivist notions. Mineral resource appraisals were provisionary in that they were time-bound and tied to a concrete social context. They provided only a momentary overview or a snapshot in time and had to be recurrently updated. Furthermore, mineral resource appraisals were dynamic in that they not only aimed to survey all ore deposits or ore-containing rocks, but did so according to economic criteria. Rudolf Nasse, head official of the Prussian state mines bureau, explained in 1893, that in a mineral appraisal, only those ore deposits were included "whose extraction seemed technically feasible and economically profitable" (Nasse 1893, 6; also Beck 1901; Launay 1912). Ore deposits, defined as "subterranean treasures," were thus given the economic meaning of 'stock' or 'inventory' ('*Erzlager*' or '*Erzlagerstätten*'), implied by the notion treasure as "an inventory of precious things" (Zedler 1737, vol. 16, col. 232 on 'Lager, Vorrath and Waaren'; Krünitz 1825, vol. 140, 453 on 'Schatz').

The encyclopedia entries indicate that the economic framing of 'ore' and 'ore deposit' had its roots in the cameralistic or state sciences in the German-speaking countries of the eighteenth century. These sciences embraced the idea of economically organized nature lending itself readily to the service of society (Lindenfeld 1997, 28-9). Hans Carl von Carlowitz (1713), in his *Sylvicultura Oeconomica*, and Carl von Linné (1749) in his *Oeconomia Naturae*, for instance, argued that nature's economy, i.e. nature's perfect organization according to the principles of rationality and utility, testified to the existence of a divine creator and administrator – a conviction known as physicotheology (see Worster 1977, 31-2; Trepp 2009, 306-72). While the renewable resources of

[1] For the emerging distinction between 'reserves' and 'resources' according to criteria of profitability and certainty of knowledge on the existence and size of resources, see Blondel and Lasky (1956); McKelvey (1972); Pratt and Brobst (1974, 2).

agriculture and forestry were subject to the "quantifying spirit" from the mid-eighteenth century onwards (Frängsmyr, Heilbron and Rider 1990; Lindenfeld 1997, 30), geological mapping and mineral appraisal followed suit. In 1791, Saxony led the way when Abraham Gottlob Werner was commissioned to make the first comprehensive mineral survey. A better understanding of nature's mineral economy sought to increase the output of royal mines and the gains from mining concessions, two important sources of state revenue. Twenty years later, in 1811, Werner submitted his *Relation über die aus sämtlichen bisherigen geognostischen Untersuchungen im sächsischen Lande sich ergebenden Ergebnisse in Hinsicht auf das Vorkommen nützlicher, besonders brennbarer Fossilien und deren zweckmäßigste Nutzung* (Werner 1811). The title "Report on the Results Drawn from all Known Geognostic Surveys of the Saxon Territory Regarding the Deposits of the Usable, in Particular, Combustible Fossils and their most Utilitarian Use" suggests that the Freiberg professor of mineralogy embraced the idea of nature being cast in economic terms, an "oeconomia mineralium" (Reuß 1777, 11). According to the German romantic writer Novalis and his modern interpreters, Werner shared the physicotheological views of his time. Novalis, who was also a civil servant trained by Werner for the state-run mining industry, modeled the teachers and miners of his novels after Werner, having them adhere to a paradigm of nature's utility (Heringman 2004, 177-8).

3. Globalizing Mineral Resource Appraisals

Mineral resource appraisals were first undertaken at the level of individual mines or mining districts (Westermann 2014, 23-4) and became global in the first three decades of the twentieth century. In appraising ore deposits, director of the US Geological Survey George Otis Smith claimed, geologists had to systematically check the "competitive relationships" these might have with far-flung mining sites: "The geologic relations of a Nevada ore deposit, for instance, must be observed with an eye trained to see far beyond the Basin range; the geologist needs to compare the quality and quantity of the unmined ore here with similar facts of nature that give value to the ores in other districts as in Peru or Burma" (Smith 1921, 3a). Introducing the *World Atlas of Commercial Geology* of 1921, Smith once more underscored that geological and world economic considerations were inextricably linked in mineral resource appraisal. Any "inventory of the mineral wealth of the United States" had to be further complemented "with a broad understanding of world demand and supply" of mineral raw materials (United States Geological Survey 1921, 3).

A world perspective on mineral resources had, of course, been present before: Far-flung, huge territories like China or Latin America had long spurred Europeans' imagination of mineral wealth. Early twentieth-century accounts of

the mineral resources of China, though unsatisfactory due to a lack of empirical evidence, “asserted with confidence” that the country was “immensely rich in mineral deposits,” just as Marco Polo had reported in the thirteenth century and Ferdinand Richthofen’s travel accounts had substantiated in the 1870s (Roorbach 1912, 130-53; Osterhammel 1987). This vision had long proved true for the territories discovered by Portuguese and Spanish long-distance maritime travelers seeking alternative trade routes to East Asia: Great amounts of gold and silver had been shipped from Latin America to Europe since the sixteenth century (Kamen 2002, 285-330). The desire to access Latin America’s mineral endowment guided American dollar diplomacy in the nineteenth and twentieth centuries (Friedensburg 1936, 138; Brown 1993; Rosenberg 1999; Priest 2003).

Such ideas about “marvelous possessions” (Greenblatt 1991) and direct foreign investments in their exploration notwithstanding, governments or industry initiated scientifically more robust and detailed inventories of single mineral commodities such as iron ore or coal on a more comprehensive level, that is for geographically more extended domestic territories, only after 1880. The emerging global perspective assessing mineral reserves beyond national territories was fuelled by both scientific and political factors. Most importantly, perhaps, it fitted the ongoing trend within the earth sciences to obtain global knowledge of the earth. At the turn of the twentieth century, earth sciences produced new technical images of the whole earth. Earthquake research, tectonics and meteorology mapped new global entities such as earthquake belts, shifting continents, or global volcano smoke streams, thus helping modern societies to sustain cultural and political ideas of globality (Dörries 2005; Westermann 2011). Resource geologists added another global structure to this collection of whole-earth pictures. In the 1920s, Charles K. Leith identified a “power belt” of coexisting coal and iron ore deposits stretching over the northern hemisphere “from the Mississippi Valley through Russia” (Leith 1927, 133). This Atlantic power belt was not so much a large-scale earth structure, though. In the vein of mineral economics sketched above, it was a geoeconomic phenomenon blending earthly and worldly matters. It was, as Leith put it in an earlier publication,

> an expression rather of the localized application of energy to mineral resources by the people of this part of the world. […] The controlling factor is not the amount of minerals present in the ground; this is known to be large in other parts of the world and more will be found when necessary. Controlling factors must be looked for in historical, ethnological and environmental conditions (Leith 1921, 63).

The first survey coordinated with the international scientific community was presented at the 11th International Geological Congress held in Stockholm in 1910, and dealt with iron ore. The Swedish mining industry, which sponsored the meeting, had proposed compiling this report. Its editors found the title of the volumes “The Iron Ore Resources of the World” rather euphemistic; in the introduction, they suggested a far more appropriate title “the actual knowledge

of iron ore resources" in line with two facts (The General Secretary of the Congress 1910, xiii). The survey actually covered a very small part of the earth's continental crust: Only 13.3 percent of the global landmasses had been explored and inventoried in detail (Friedensburg 1913, 77). Consequently, it was considered a general, albeit unsurprising, insight gained from the joint efforts of the earth scientists that a region's iron ore resources tended to increase with the advancement of detailed exploration work (Sjögren 1910, xx).

Estimations of ultimately recoverable global mineral resources had to remain "speculative" (Sjögren 1912, 300) and yet were attempted regularly. In order to know "how much probability is there that new, hitherto unknown iron ores resources will be discovered in the less thoroughly investigated countries," Swedish geologist Hjalmar Sjögren suggested using "an iron coefficient": "the quantity of iron, within a certain area expressed in tons, divided by the area expressed in square kilometers." The world iron ore survey had shown that the best investigated parts of the world, consisting of Europe, the US and Japan, with a total 17,368,117 square kilometers, contained roughly 7 billion tons of actual and 49 billion tons of potential reserves. "If we start from the primary supposition that the iron coefficient of the hitherto uninvestigated parts of the world's surface is the same as the coefficient of those best investigated," Sjögren explained, "we arrive at a probable figure of the iron ore resources of the entire world" (Sjögren 1912, 300). The international geological congress made other world inventories for coal (1913), phosphate (1926) and copper (1935).

Large-scale inventory efforts served national political interests, too. The tenth US census of 1880, published in 1886, which included a *Report on the Mining Industries of the United States (exclusive of the precious metals) with Special Investigations into the Iron Resources of the Republic and into the Cretaceous Coals of the Northwest*, is one of the milestones in this respect. The report was assigned to the US Geological Survey founded only a year earlier in 1879. Elaborate questionnaires and classifications were created for the census report. The report aimed to catalog and appraise the mineral resources with which "the material prosperity of the United States of the 20th century must be built" (Pumpelly 1885, 3). The census report laid the foundations for an annually updated collection of data published by the US Geological Survey, the US metal statistics. Arguably, these statistics were the most important result of the 1880 effort. Together with the "metal statistics" of the German multinational Metallgesellschaft AG, the US Geological Survey commodity reports and yearbooks of minerals evolved into a widely cited tool for the international mineral resource sector, a 'backbone institution' in the world of metal raw materials.[2]

[2] According to Friedrich-Wilhelm Wellmer, former president of the Federal Institute for Geosciences and Natural Resources (interview 13/09/2013). The collection at Metallgesellschaft AG was started in 1893, see: Hessisches Wirtschaftsarchiv, Abt. 119, Nr. 646, Statisti-

At the turn of the century, the need for global self-positioning of states in regard to mineral wealth was being articulated with increasing frequency. Rudolf Nasse's *Die Kohlenvorräthe der europäischen Staaten, insbesondere Deutschlands, und deren Erschöpfung* [The coal reserves of the European States, Germany in particular, and their exhaustion] of 1893 provided an early version of what became the typical line of reasoning. It is interesting to recall the survey's original task: In the summer of 1890 the Prussian Minister of Commerce, Baron von Berlepsch, asked the state mines bureau – Nasse was one of the head officials – to ascertain the size of the coal reserves stored in the state's various deposits of bituminous coal, as proven by actually mined exposures and estimated by inferring from general geognostic knowledge of the territory (Nasse 1893, 10). Nasse explained why he had broadened the assignment considerably and included in his report studies on the coal reserves not only of Prussia but also of the German Reich and Europe, and why he had even given numbers for the entire world: "Only by comparing the reserves, does the single result become meaningful" (Nasse 1893, 11).

Based on global inventories of mineral resources and a wealth of new statistical data, the global positioning of states and global self-positioning slowly became routine endeavors: How large were one's own domestic stocks of natural resources compared to global stocks and global production? In posing this question, the emerging field of mineral economics combined a national and a world economic perspective. In this, it differed from the earlier cameralistic calculations regarding mineral resources. Moreover, research was directed towards determining "worldwide deposits of a certain mineral or at least those ore deposits located within the world-trading countries" (Krahmann 1903, 1, 3).

Consequently, interwar reports were synoptically organized according to a range of different mineral commodities and the "mineral position" of nation-states. They addressed the questions of what was the amount of most important minerals globally, and how this mineral wealth was distributed nationally. In the same vein, geologists determined a nation's "mineral factor in the world position," its "Rangordnung" or "present mineral position" (Smith 1919; Friedensburg 1936, 50; Leith 1943, 32; Pehrson 1946). There were rankings like these:

> In 1913, the United States ranked first in the production of 13 out of the 30 most important mineral commodities and ranked second in four others. […] Russia, Austria and Spain each ranked first in the production of two of the 30 commodities and second in one (United States Geological Survey 1921, 4).

In their composition, the new reports contrasted both with academic textbooks where ore deposits were classified according to major mineral occurrences of the same genetic origin, and also with the first global inventories of single minerals. Yet another feature emerged: Mineral availability was no longer only

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sche Zusammenstellungen über Blei, Kupfer, Zink und Zinn von der Metallgesellschaft Frankfurt am Main in den Jahren 1890-1892.

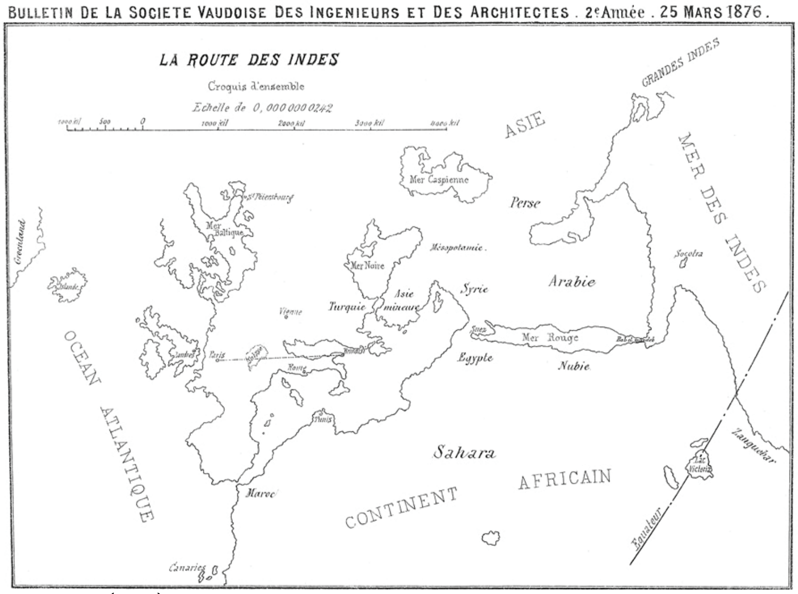
defined in terms of "economic viability," as had been the case in classic mining geology. It became equally important to know whether mineral resources were *politically* available or accessible: Geological surveys or mining institutions investigated which states possessed the "commercial control" of perhaps remote mineral sources and were therefore in a position to disrupt or divert the global mineral flows to their own strategic advantage (Spurr 1920; Rawles 1933).

4. Casting Mineral Resource Appraisal and Supply in Functionalist Language and Images

In the aftermath of the raw material shortages of World War I, geologists started to cast mineral resource estimates and supply in a functionalist language – thus making explicit the place of industry, economy, consumption and international politics within the mineral resource business. In its most general form, the issue was approached by accounts of how the industrialized world had come about and explanations of the crucial roles played in its creation by coal and iron. An introductory lecture in mineral economics in 1932, for instance, underlined that minerals were of critical importance to industry, supplying "both the power and the machine" (Tryon and Berquist 1932, 5). German geologist and mining engineer Ferdinand Friedensburg added that world transport equally depended on the availability of coal and iron ore (Friedensburg 1934, 9). US geologist and technocrat activist Marion King Hubbert arguably provided the most radical functionalist or cybernetic description of mineral resources: "Modern industry may be conceived of as one vast flow-line of minerals flowing from the earth by way of the mines into industry, and finally, by wastage and chemical disintegration, returning to earth again" (Hubbert 1934, 19).

The idea of "world transport" was a functionalist concept in itself, where large technical networks of connection and synchronization had furthered the vertical and horizontal consolidation of big industries such as the metal industry (Geistbeck 1895, 526-30) and allowed for the worldwide control of supply chains, i.e. the "absorption, storage and distribution of commodity flows" (Rathenau 1925 [1916], 49). The world map "Le Simplon et la route des Indes," for instance, with its special outline made by the Lausanne engineer Eduard Pellis in 1876, illustrates the idea of an engineered global transportation network of the shortest lines (Fig. 1). On Pellis's map, the long-discussed Simplon Tunnel is depicted as a direct prolongation of the "almost linear Red Sea and the newly opened Suez Canal both pointing straight to Europe" (Pellis 1876, 1). On this map, the Simplon Tunnel appears as the second-last section to be realized on the direct route from India to London. The last stretch would be the Channel Tunnel.

Figure 1: The Simplon and the Route to India



Source: Pellis (1876).

Not only mineral resource supply but also mineral resource appraisals were conceived in functionalist terms, as Friedensburg's outline shows where the size of mineral reserves was a "product" or function of "variable factors": "All metals are dispersed more or less thinly over the entire earth's crust; exactly when an aggregation becomes a deposit to be mined at a profit ("*bauwürdig*") and hence enters the cycle of the supply reserves for the earth, is not so much dependent on the grade of concentration but rather of the circumstances determining the costs of potential utilization. The quantity of usable reserves of a certain raw material is quite a relative notion, a product of several variable factors of which the actual costs and the price of the product are the most important" (Friedensburg 1936, 73-4).

German-born economist Erich Walter Zimmermann, who had started out researching world transportation issues such as British coal exports and international trade and shipping (Zimmermann 1911, 1917), ended up suggesting a functional approach to natural resources and their appraisal. In 1933, he published *World Resources and Industries: A Functional Appraisal of the Availability of Agricultural and Industrial Resources*. From a social science perspective, Zimmermann offered a comprehensive assessment of the human, cultural and natural factors determining resource availability. He defined resources as a function of human wants and abilities: only aspects of "the environment in the service of man" could be regarded as natural resources. "A man-less universe"

would be void of resources, he argued (Zimmermann 1933, 3). In 1942, he was given one of the first professorships of natural resource economics at the University of Texas.

5. New Methods of Mineral Resource Appraisal

Functionalist portrayals of global mineral resource appraisals explained and reflected on the complexities of determining mineral reserves for large-scale portions of the earth in an exercise of popular enlightenment. In doing so, geologists spread as news what was by then well known among experts. At the same time, functionalist thinking also guided their research into new methods of mineral resource estimation. These attempts to appraise mineral resources by linking geological and social scientific data contributed to the gradual development of mineral or natural resource economics as an academic discipline which, in the second half of the twentieth century, became indispensable for the management of natural resources (Westermann 2014).

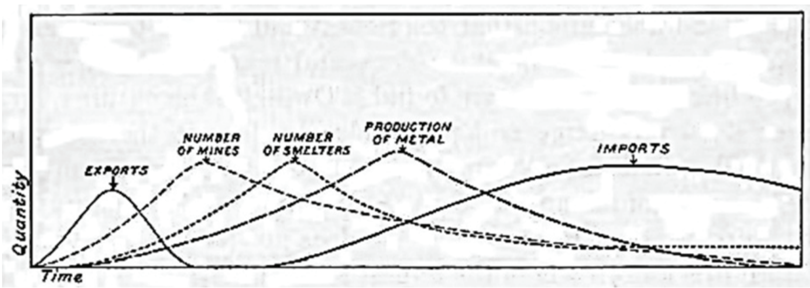
Donnel Foster Hewett of the US Geological Survey, for instance, proposed an appraisal method which would serve after 1945 as a model for Hubbert's estimates of petroleum production in his "peak oil" model (Hewett 1929; Hubbert 1975, 9-11). During a trip to Europe in 1926, Hewett visited twenty-eight mining districts and about fifty mines, many of which were or had been outstanding sources of different metals in the past. In his search for the "record or evidence of the stages of life in the metal industries," he also turned to the many studies which European, in particular German and Austrian historians, economists and engineers had dedicated to the history of metal production. Hewett felt that Americans could benefit from reviewing the experiences in mineral exploitation acquired by the Europeans with "a record of metal production extending back nearly 3000 years" (Hewett 1929, 3). The report was reprinted in Tryon and Berquist's (1932) collection of articles on "mineral economics," thus enjoying a larger circulation than the original technical publication of the American Institute of Mining and Metallurgical Engineers (AIME).

Hewett aimed to systematically relate existing data on mineral industrial activities and the magnitude of unknown ultimately recoverable ore resources of a country. His approach of determining metal production trends took the production numbers of individual mining districts as the base unit for national statistics. The cyclical patterns Hewett found in reviewing the history of the single mining districts showed slow initial production preceding rapid growth as readily available resources were mined, followed by peak production and slow decline as the remaining resources became more difficult to harvest. In other words, different stages of a production cycle could be distinguished by observing which of the successive economic activities listed below peaked in any given area:

1) exports of crude ore;
2) number of mines in operation;
3) number of smelters in operation;
4) the production of metals from domestic ore;
5) the quantity of import of crude ore (see Fig. 2).

By identifying its current peak activity, Hewitt maintained, a region or country could determine how far it had progressed through the stages of rise or decline of metal production and assess the amount of recoverable mineral resources left for use in its territory (Hewett 1929, 26).

Figure 2: "No significance is to be attached to the relative heights attained by these curves; I wish only to emphasize the successive relation of the peaks." Donnel Foster Hewett's Stages of the Metal Industries for Countries with Fuels



Source: Hewett (1929, 27).

Hewett firmly embraced the idea that forecasting the future demanded a thoroughly historical perspective. The idea was gaining ground in the social sciences, too. The "cycles in metal production" resonated with the "business cycles" explored at the same time by the National Bureau of Economic Research, established in 1920 in New York, or the *Institut für Konjunkturforschung* in Berlin, established in 1925 (Fabricant 1984, 7). Many research institutions dedicated to the explanation and theoretical foundation of observed "cycles" or regular fluctuations as the normal course of capitalistic economy had been founded after the war. Wartime state economic planning had been in dire need of macroeconomic data and time series. In view of future state action, research on business cycles was to uncover past economic patterns and trends (Tooze 2001, 103-48).

6. Technocracy in Action

The war created a new sensitivity for the issue of natural resources among the Entente and Allied powers: Former sources of supply had been cut off by the war's interference with commerce while military industrial expansion had caused increased consumption of raw materials. As a result, German, French and US geologists and metal raw materials experts started to deal extensively with the geopolitical dimensions of mineral resources (De Launay 1918; Merton 1931; Friedensburg 1934). Longstanding political conflicts like the Alsace-Lorraine question were now referred to as struggles over mineral resources, in this case over the greatest iron ore deposits of Europe. "How many realize that the Alsace-Lorraine question is and was not a sentimental one, but a struggle for the greatest iron deposits of Europe and the second largest in the world? That the dispute between Poland and Germany as to Upper Silesia is not a question of nationality, sentiment or even territory, but concerns the greatest coal field of Europe as well as great deposits of lead and zinc?" (Spurr 1920, vi, 38-41) Some geologists had been appointed political advisors to their governments. Charles Kenneth Leith, for instance, had been a member of the US Shipping Board and War Industries Board and accompanied the US delegation under Bernard Baruch to Paris in order to negotiate peace in Versailles (Priest 2000). Also, earlier conservationist ideas about "minimum waste of non-replaceable materials" were addressed with new urgency (Hubbert 1943, 13 (24 in the pdf file)).

The interwar period saw the heyday of technocracy. Geologist Hubbert located the origins of the technocratic movement in the US in the experience of war economic planning: "The way this organization came into being was through the association of a number of people here in Washington during the last war. That association arose from experience in the war agencies, the War Industry Board, I believe it was called then, and various other Government agencies" (Hubbert 1943, 5 (15 in the pdf file)); on the US Shipping Board see Spurr 1919).[3] Only because people, as we have seen, conceived national and international economies as functional systems could they claim to be in the position of engineering or regulating them (Veblen 1965 [1921], 52-6). Technocracy was defined by one of its US observers as "a method of scientific procedure in operating a mechanism of a continental order of magnitude" (Parrish 1933, 32). World

[3] During World War II, Marion King Hubbert worked for the Division of Supply and Resources at the Board of Economic Warfare. In April 1943, the Board subjected him to questioning because the US Civil Service Commission had considered him unsuitable for the job due to his membership at Technocracy Inc., at the time considered "fascist in its setup and objectives" and envisaging "a form of government not democratic in character" (United States Civil Service Commission 1943, 7; see also the interview with Hubbert in Doel 1989, session IV).

planning had definitely become an option. “Knowledge of what the whole world contains,” the *World Atlas of Commercial Geology* argued, “is plainly the best basis for discussing public policy and planning private business” (United States Geological Survey 1921, 4; see also Veblen’s 1965 [1921], 143 call for “Resource Engineers”).

From a conservationist and functional perspective, economists started, for instance, to deal with the question of how to use up non-renewable resources most efficiently (Hotelling 1931). Metal scrap recycling, systematically enforced during World War I, was an alternative way of enhancing the efficiency of metal raw materials consumption. Metallgesellschaft AG organized the “*Kriegsmetallgesellschaft*,” one of the several war economic planning boards managing the German “raw material economy” during World War I (Rathenau 1925 [1916], 25). Since, by and large, Metallgesellschaft AG had controlled the German commercial and industrial network of nonferrous metals before 1914, a smooth operation was secured.[4] Nonferrous metals like copper, zinc, lead and nickel were needed for self-contained metallic cartridges in Europe. In view of trade embargoes, the network began dealing in scrap metal. The recycling of scrap copper made Germany the second largest producer in the world (500,000 tons), after the US – albeit that Anaconda’s Montana mines alone produced more copper than all Europe during the war, as William Yandell Elliott of Harvard’s Bureau of International Research, who had also been Vice President of the War Production Board in Charge of Civilian Requirements, was eager to emphasize (Elliott 1937, 407).

Geologists acknowledged that with these and other calculations accounting for shortages and autarky in mineral resource supply, the “organically grown exchange” in mineral affairs (Friedensburg 1936, 130), the “natural course of commercial evolution“ (Smith 1921, 3a), the “natural channels of the international flow of minerals” (Leith et al. 1933, 6), and “the more or less spontaneous internationalization of mineral resources by private enterprise” (Leith 1921, 8a), could be deflected in the short run. To them, autarky was not a long-term option, however, given that world mineral resources were unevenly distributed geographically and no single state was endowed with everything it needed for economic and technological advancement – not even the resource-rich United States (Smith 1921; Friedensburg 1936, 69-70; Krahmann 1928, 20, 135). That even during periods of economic nationalism, such as the 1930s, a full third of the minerals were traded worldwide only substantiated this conviction

[4] In 1914, Metallgesellschaft was the one major European member of the world copper oligopoly. Moreover, the company had made itself the central selling agency of the international lead and zinc syndicates (Chandler 1990, 488). Also, for about a decade and a half, until 1914, it held the trading monopoly of Australian lead and zinc ores for continental Europe, by reaching an agreement between the three German nonferrous metal and mineral ore traders for the joint purchase of Australian zinc ores.

(Friedensberg 1936, 130). Moreover, the global outlook would become ever more important, since the proportion of global production in major consumer countries, including the United States and Germany, would decline over the twentieth century.

The experts tended to lobby for long-term engineering or regulation of the global mineral material flow and propelled a mineral resource management where industrial organizational expertise and scientific knowledge coalesced to support the making of national and international raw material politics. A secure system of mineral resource supply would remain a staple for any "far-sighted handling of international relations," they argued (Leith 1921 [1918], 16a; Friedensburg 1936, 9, 97). In 1927, Berlin geologist Max Krahmann extended an "invitation to co-operate" to his colleagues, pleading for an international association connecting international efforts of mining economics and aiming at the establishment of a future "International Institute of Mining Economics" (Krahmann 1928, 12 for the English version). Krahmann had presented his views on the methods and aims of geoeconomic inventories to the International Geological Congress in Madrid in 1926. The same year, he submitted a proposal to the League of Nations regarding the creation of an "International Mining Institute" modeled on the International Institute of Agriculture of 1905, the UN Food and Agriculture Organization's (FAO) predecessor (Krahmann 1928, 135-6). He underscored that mineral statistics suffered from incoherent and deficient data collection: "Under the methods at present employed in the different countries in estimating the geological reserves or so-called inventories of mineral deposits, the technical possibilities of extraction and commercial exploitability which vary greatly from time to time and from place to place, comparison is not possible and these deposits cannot therefore be included in a common total without leading to erroneous conceptions." Further defects needed to be remedied, such as the neglect of the question of consumption, i.e. the lack of research into requirements according to raw material properties and raw material market and price development. In short: the International Mining Institute should act as a clearinghouse for international political, economic and scientific cooperation in the field of mineral resources. Its chief concern would be to "examine the question of establishing inventories of the world's deposits" (Krahmann 1928, 15). Krahmann presented his suggestions as "a program to rationalize world economy" by advocating a technocratic approach to the raw materials sector: to him, the acknowledgement that "mineral economics was gradually becoming world politics" was a vital prerequisite for devising methods of political and economic intervention (Krahmann 1928, 21).

Against the background of demographic growth, similar visions were elaborated in the field of world population management. Accelerated rates of population growth were the traditional flipside of natural resource availability. At the World Population Conference in Geneva of 1927, for instance, the director of the International Labor Office, Albert Thomas, dreamt of a world "populated in

accordance with […] local fertility and productive capacity." He suggested creating a "supreme super-national authority which would regulate the distribution of population on rational and impartial lines, by controlling and directing migration movements and deciding on the opening-up or closing of countries to particular streams of immigration" (Thomas 1927, 262).

Geologists found people and institutions ready to listen to their suggestions regarding global mineral resources. State agencies planned to build strategic mineral stocks in order to prevent wartime shortages in the future; they encouraged private mining companies to invest in mineral exploration and mining abroad and to reach international commodity agreements. International agencies such as the League of Nations and private organizations such as the US Brookings Institute, the Geneva Research Centre, or the Berlin Institut für Konjunkturforschung extensively studied world mineral supply and demand with a view to identifying and managing economic and political resource conflicts among nation-states and world regions. As one of the many reports on international raw material policy put it: "The problem of raw materials actually became the test case in terms of which the representatives of the various countries tried to define the field of the League's activity" (Kapp 1941, 23). A social scientific approach to international relations not only facilitated quantification efforts but also led to qualitative research in the field of mineral raw materials production and trade (Guilhot 2011, 129). Economist Albert O. Hirschman, for instance, began investigating the power hierarchies created and sustained by international trade. His book *National Power and the Structure of Foreign Trade* (Hirschman 1945), written during World War II, combined quantitative and qualitative approaches. In it, Hirschman remained skeptical as to the mutual benefit of international raw material trade and helped lay the foundation for a critical discourse on mining and mineral raw material trade within the United Nations. These collective actors and their interests became permanent stakeholders in the international mineral supply system. The first scientific conference of the United Nations, which took place in 1949, was dedicated to the *Conservation and Utilization of Resources* (United Nations 1950). Krahmann's vision of an international mining institute under the umbrella of the League of Nations eventually materialized in 1994 as the UN International Seabed Authority took up its work – dealing, however, exclusively with the metal ore deposits of the deep sea.

7. Conclusion

In the interwar years, geologists, often in collaboration with economists, offered mineral resource appraisals as tools for analyzing or organizing international relations. They lobbied to make mineral resource knowledge a staple of both national economics and international political economy.

Two trends combined to make mineral resources amenable to international political management. First, a global perspective was added to the national economic focus of mineral resource estimates passed down from the cameralistic origins of mining and geology. Second, both international mineral resource supply and mineral resource estimates were addressed in a functionalist language in order to fit the interwar technocratic ideas of planning and maintaining world order. Together, these trends suggested that world mineral reserves were meaningful, if provisionary, numerical descriptions linking knowledge of the earth to knowledge of modern societies and thus informing political and economic decision-making on a global scale.

Against the background of autarkic ambitions and war economy, the 1930s and 1940s saw other forms of geopolitical calculations arising in the field of mineral resources. Not only was metal recycling advanced in the name of resource scarcity or improved resource efficiency. On an unprecedented scale, scientists and engineers also started to research and develop raw material substitutes and hence to set different – fuel and nonfuel – mineral resources against each other on the natural capital balance sheet.

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